Reworking of Indium bump bonded pixel detectors

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Reworking:first tests

The chip stripping machine

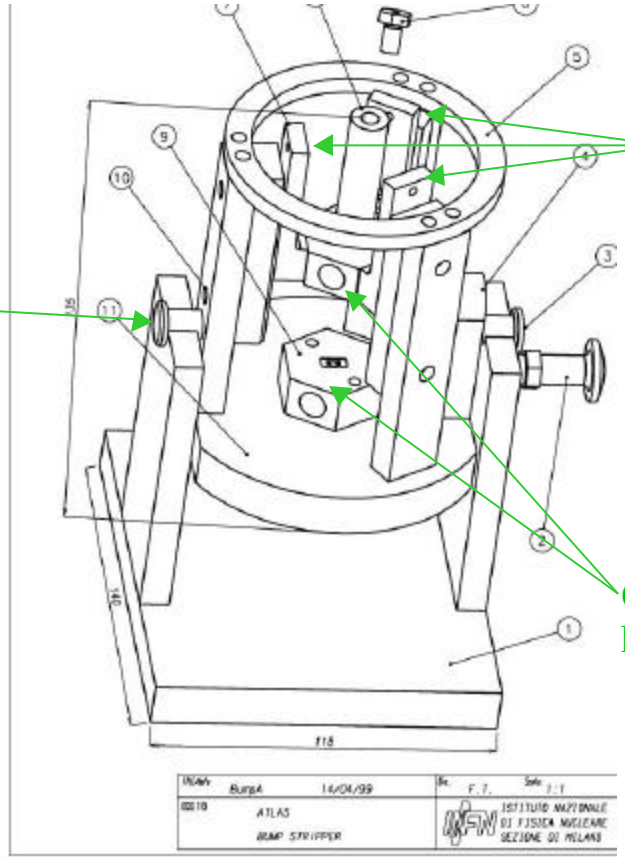
Conclusions: first results

Reworking?

- For pixel detectors, due to the contact density and the required single bump failure ($<10^{-4}$), the only interconnection technique is bump bonding on flipped chips
- Moving from a detector prototype to a full scale system requires a production chain optimization where hybridization plays a crucial role
- In current HEP applications up to 16 chips are attached to the same sensor; replacing a faulty chip (“reworking”) could considerably improve the yield. For instance in the DELPHI pixel detector the module production yield after bonding of 16 known good chips was ~80% and a good part of the faults were on a single chip

Feasibility study

- The first tests have been performed at Politecnico di Milano, using a dynamometer operating in a temperature controlled environment



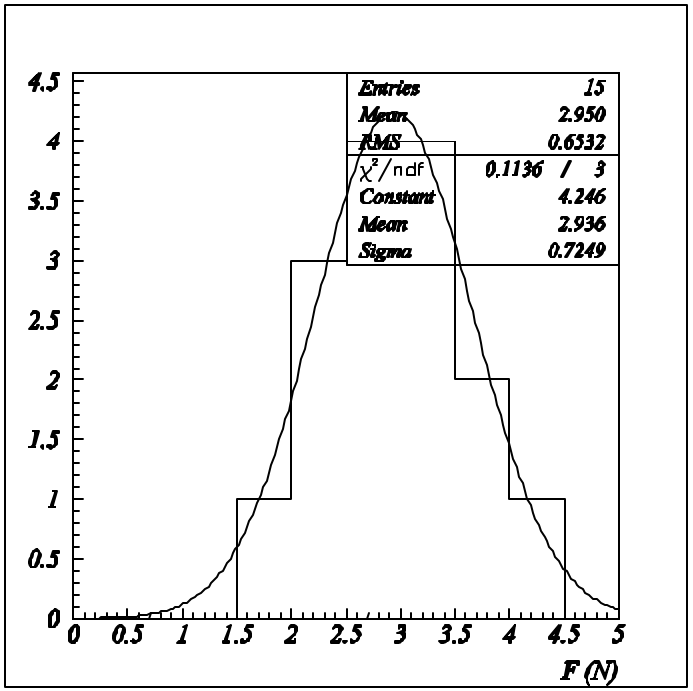
The upper holder is connected to 3 slides to absorb any shear stress component

The "sandglass"can turn around this axis so that, after the stripping, the 2 chips can easily be picked-up

Chip vacuum holders

Results

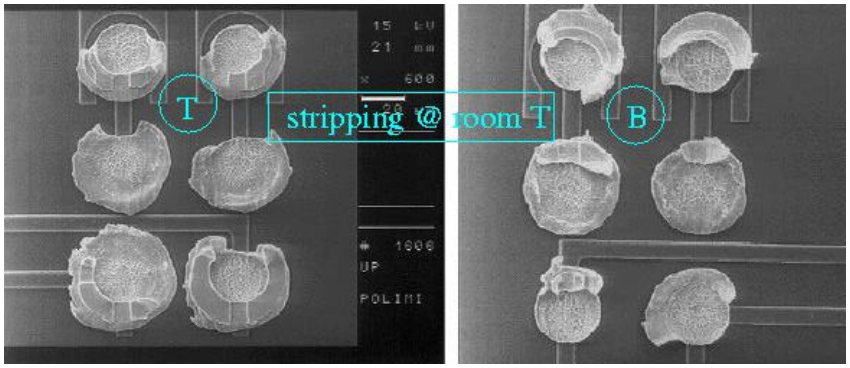
The dispersion of the tensile strength and the quality of the re-worked chips (“mechanics grade”assessed) looks fair

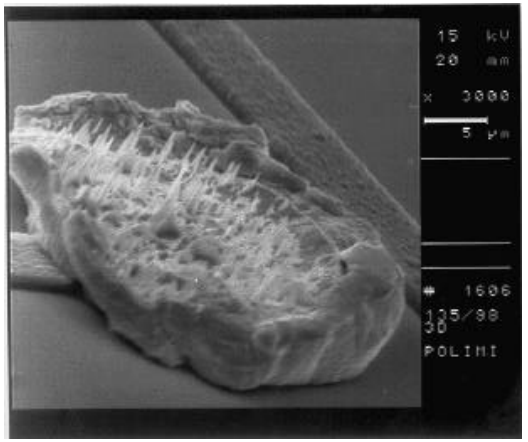


Visual inspection confirms the good quality of the stripped bumps

Test conclusions

- Reworked assemblies are quite good in terms of mechanical strength and single bump failure
- Reworking with In bumps has been shown to be possible
- Care has to be taken in:
  - Removing the chip with the same planarity it has been attached (<0.1 mrad) to prevent shear stress to cause asymmetric bump breaks
  - Warming up (~100 C) the bonds to exploit In plastic characteristics





Conceptual design

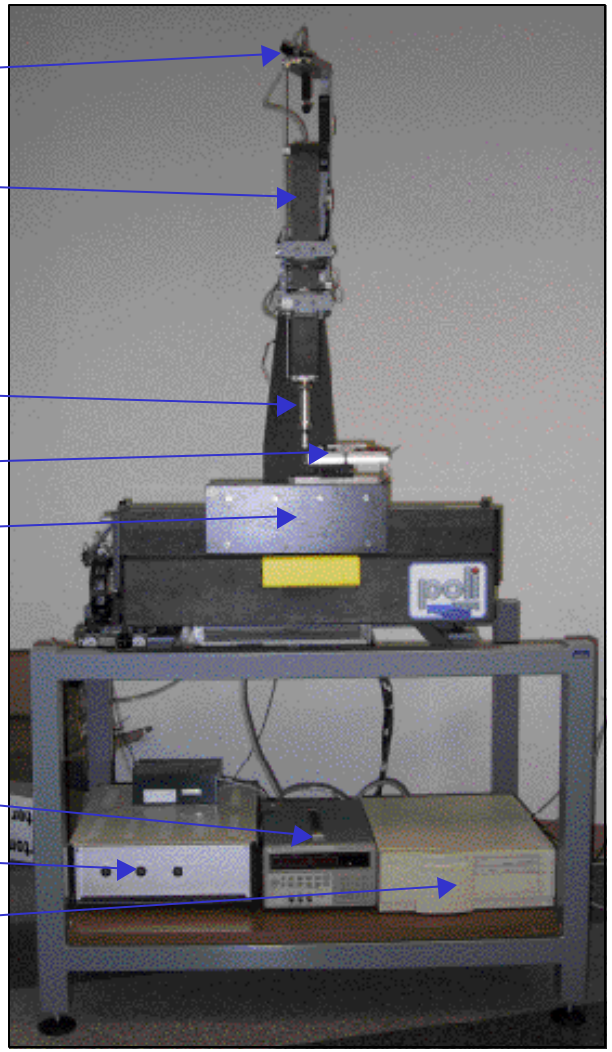
- ...basically a microscope with few added features!
  - Micrometric positioning
  - Vacuum module holders
  - Module heater
  - Everything PC controlled

Actual machine

- Venturi vacuum pump
- Z axis

- Pick-up tool with load cell
- Hot plate with Peltier cell
- X, Y stage

- Peltier power supply
- Motion control power unit
- Everything PC controlled



Let's take a look at the single components…

Poli Comet II

Coordinate measuring machine (CMM) by Poli, Varallo, Italy that guarantees the needed planarity

Pneumatic guides of the granite moving XY axis and pneumatic balancing of the Z axis

Maximum travel of 400x300x250 mm (X,Y,Z).

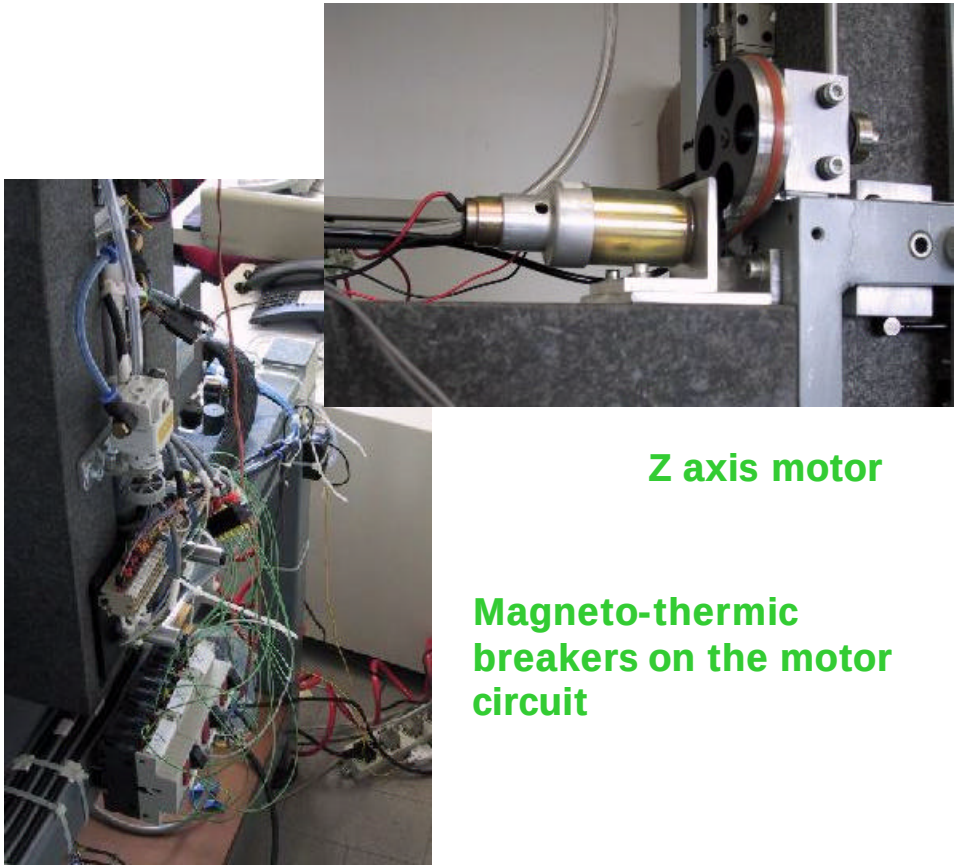
Optical encoders with a resolution of 1 µm

About 1x1x1 m dimensions and 140 Kg total mass

Motion control

- NI 7344 controller up to 4 axis (3 implemented)
- Mini Maestro servo motor Pulse Width Modulation power units

PWM power units

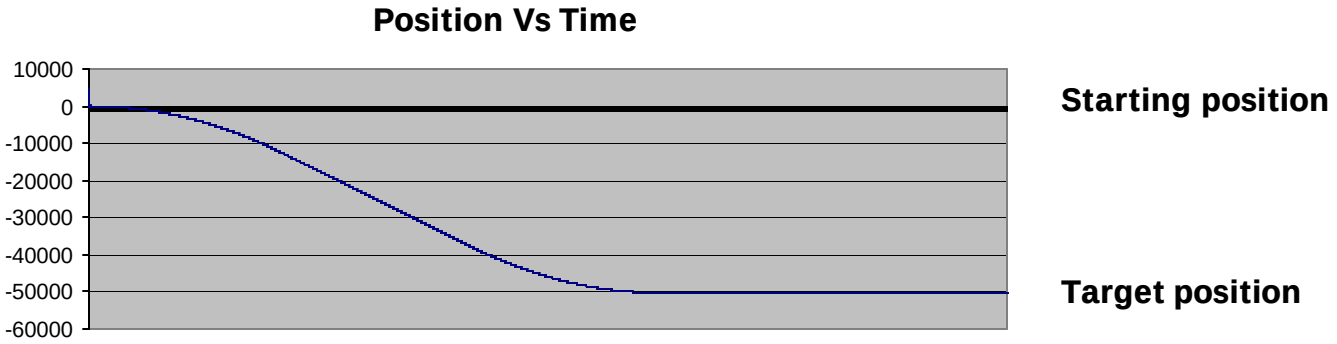


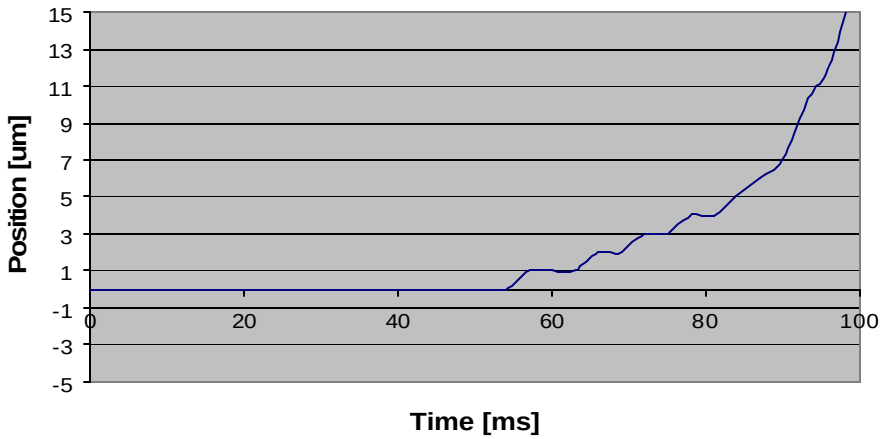
Z axis motor

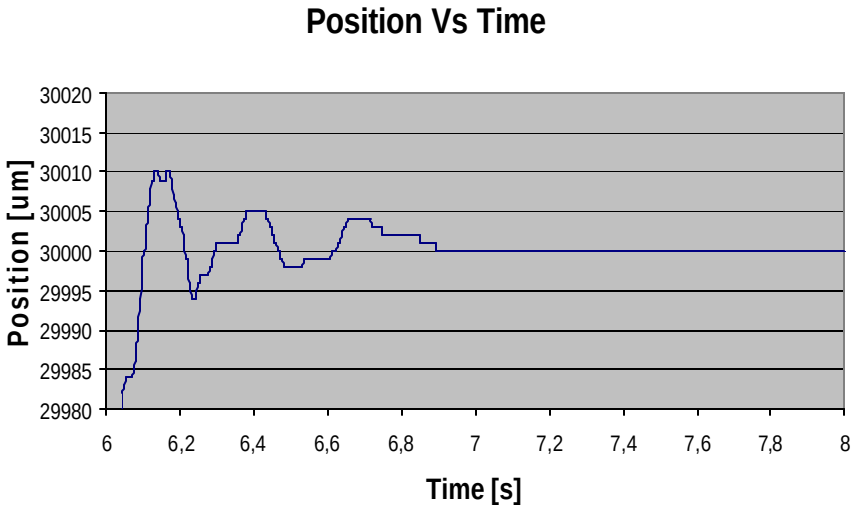
Magneto-thermic breakers on the motor circuit

Motion control (2)

- Performances after PID parameters have been optimized

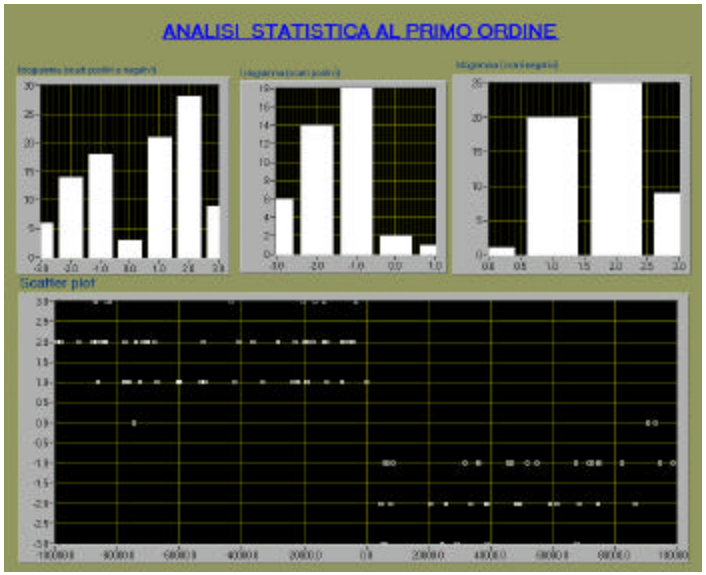


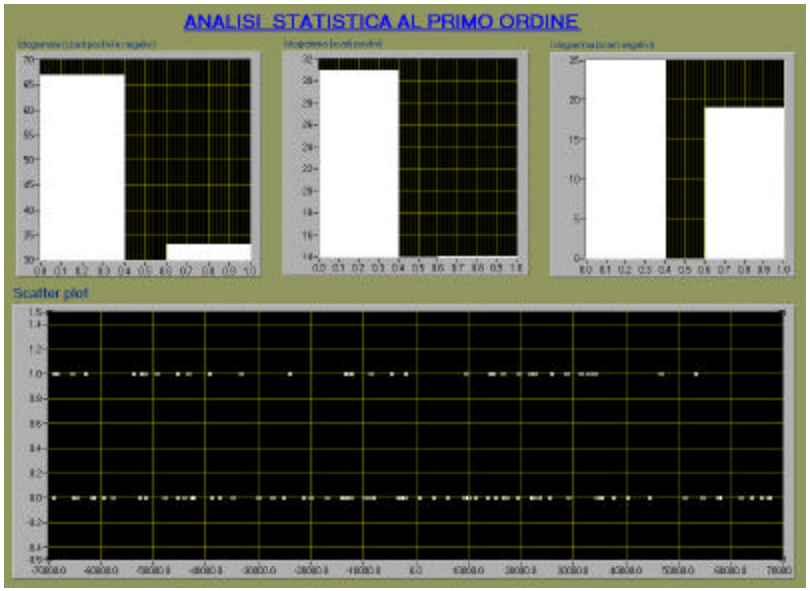




Motion control (3)

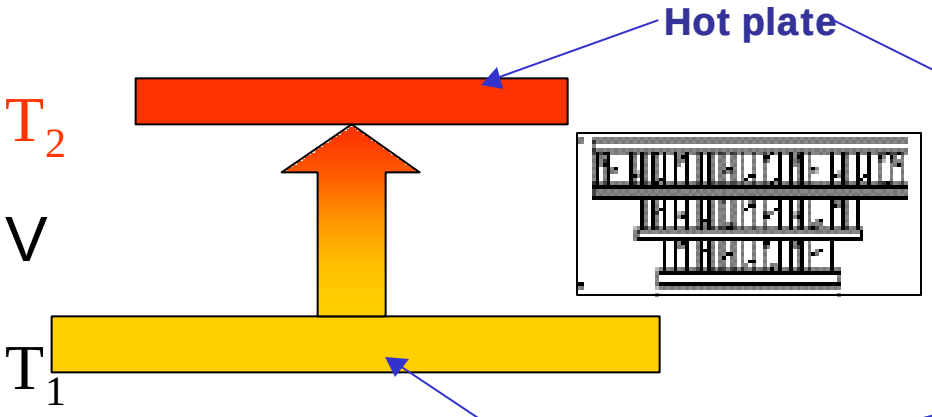
- A double PID has been introduced to better maintain the target position after it has been reached: the “approaching” PID is changed to the “stationary” PID after being within few microns from the target position for at least 300 ms.

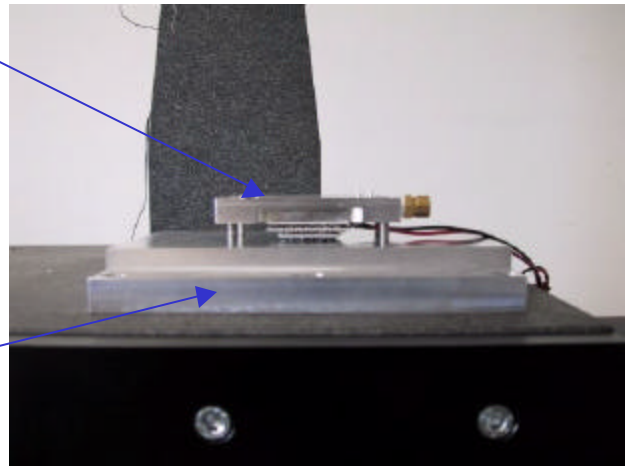


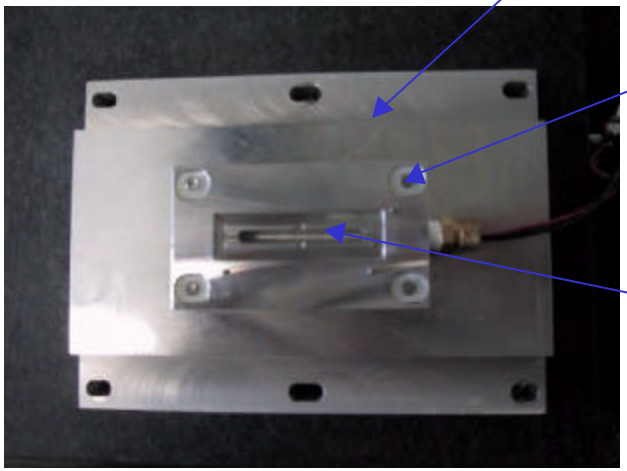


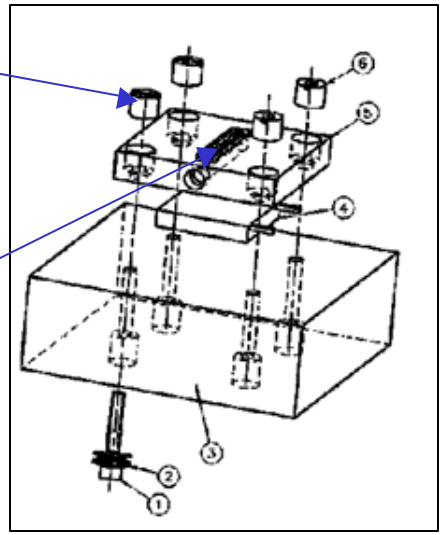
The error is smaller and it does not depend any more on the approaching direction

Peltier cell



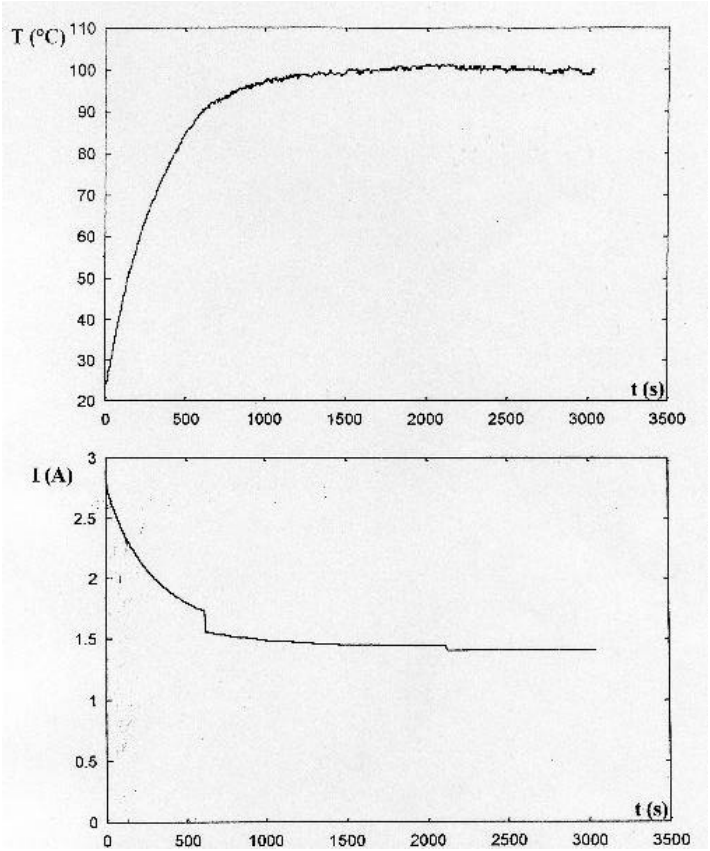






Peltier cell (2)

- Peltier cell is biased by a GPIB controlled power supply
- The hot plate temperature is read out by thermistors: a PID loop reaches and maintains the needed temperature



Pick-up tool

Vacuum from Venturi

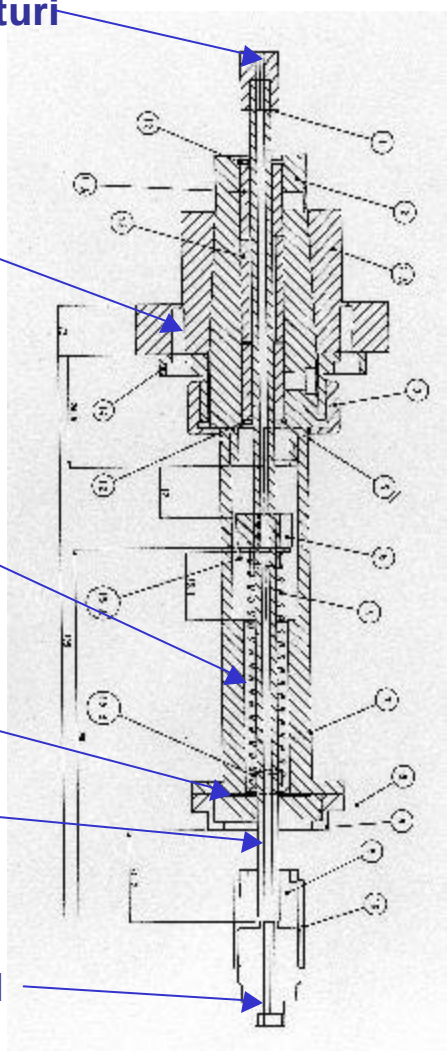
Connection to Z axis

Spring on load cell

Load cell

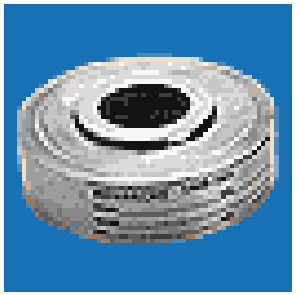
Moving vacuum pipe

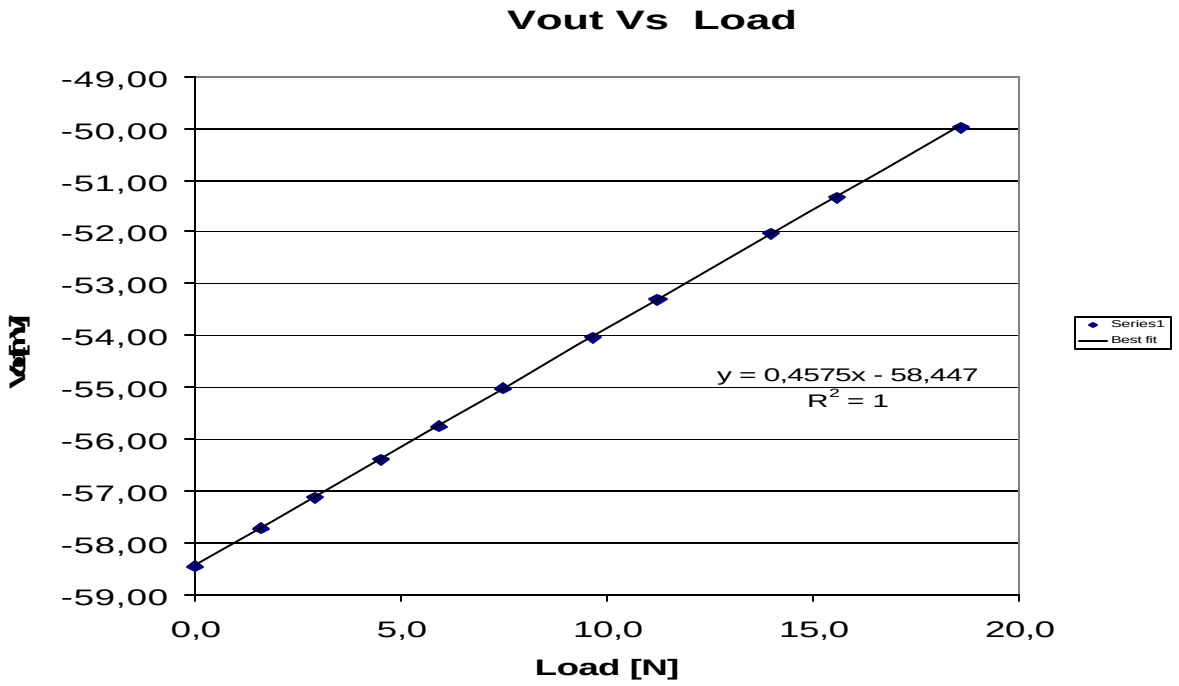
Teflon touching tool



Load cell

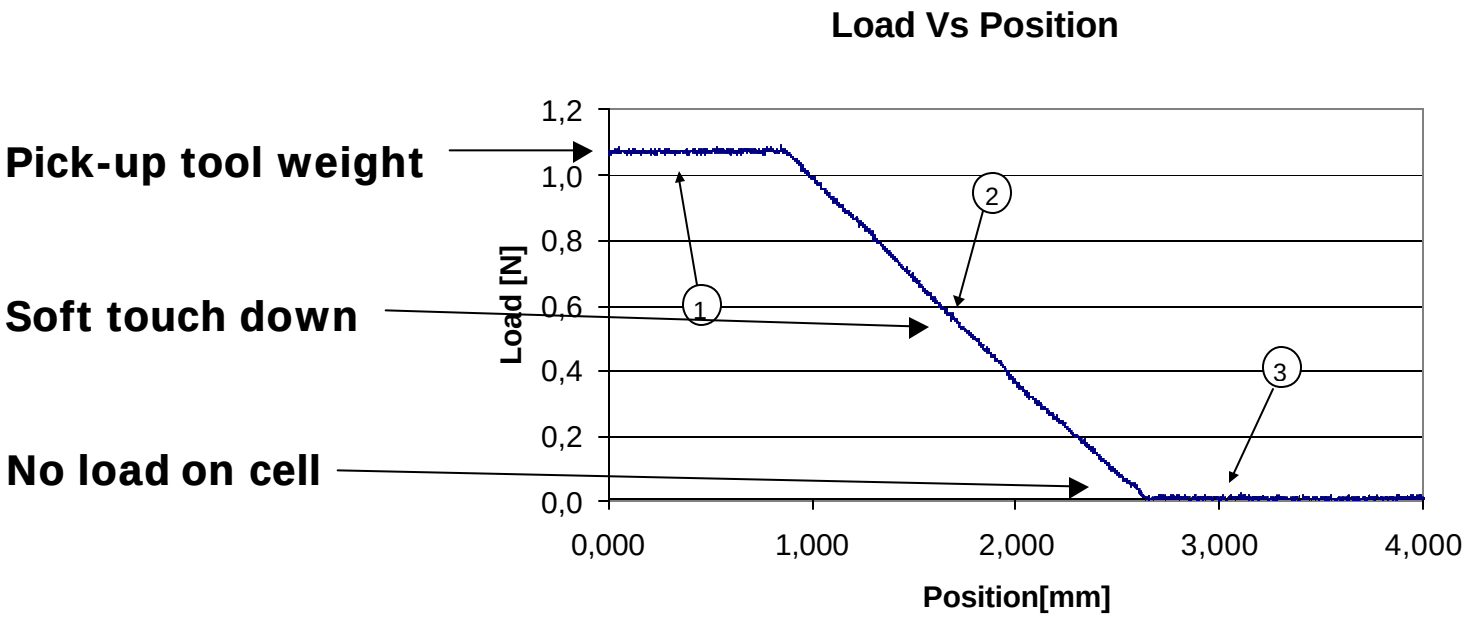
- Wheatstone bridge





Touch down

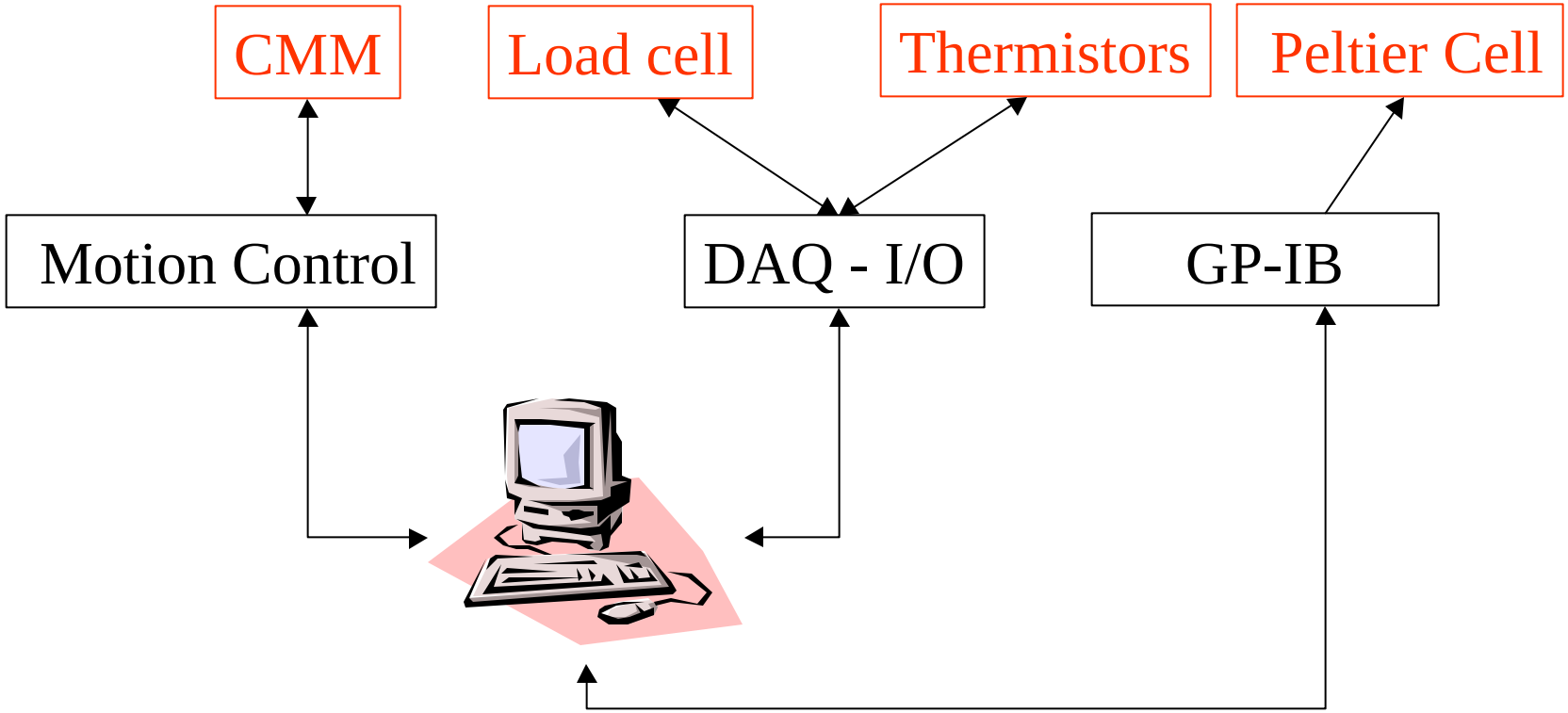
Maximum load on chip is the pick-up tool weight…



…do not worry: there is also a safety stop on the Z axis position!

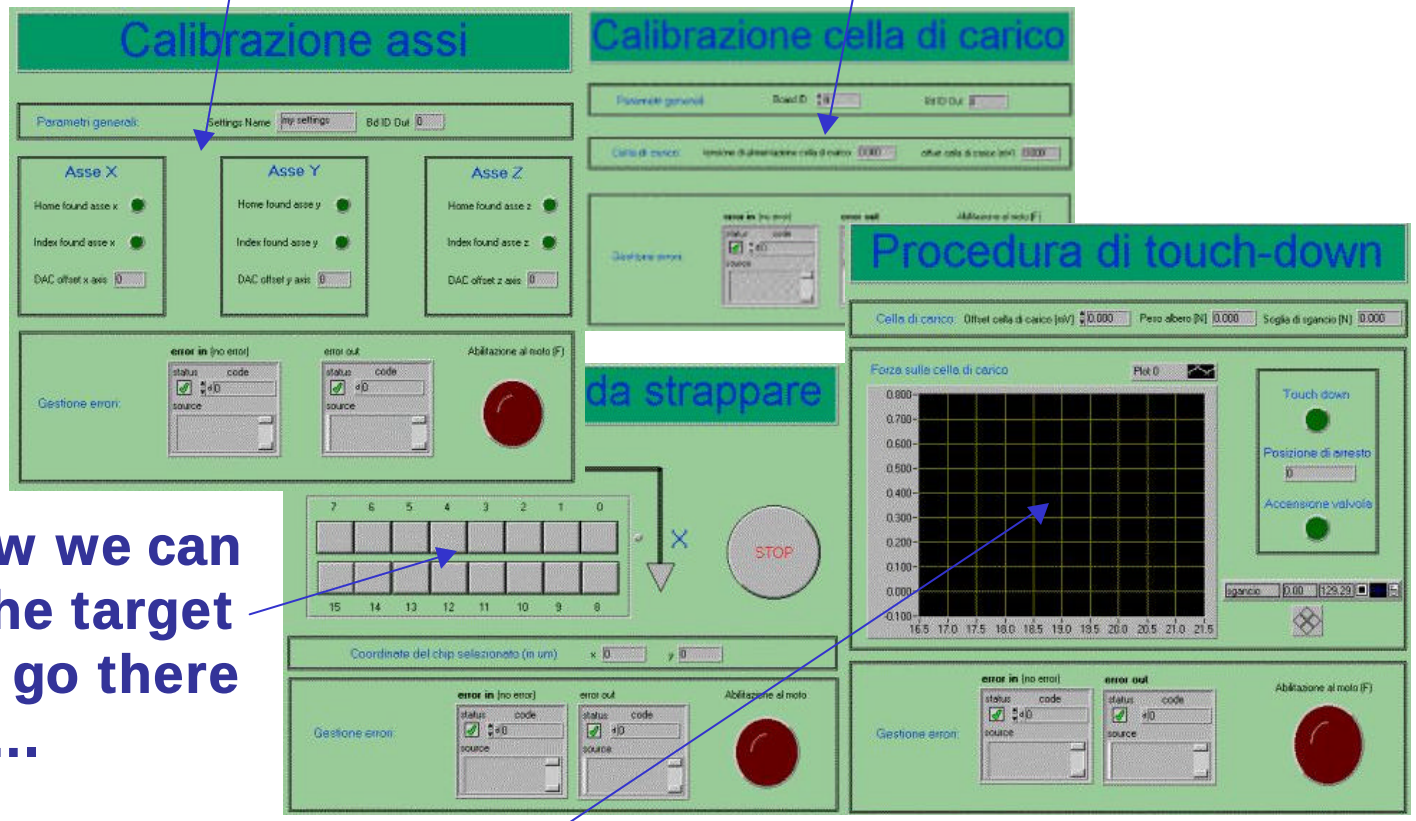
Software

LabView code to control the integrated system



Software (2)

First let's check and calibrate the axis motion control and the load cell…

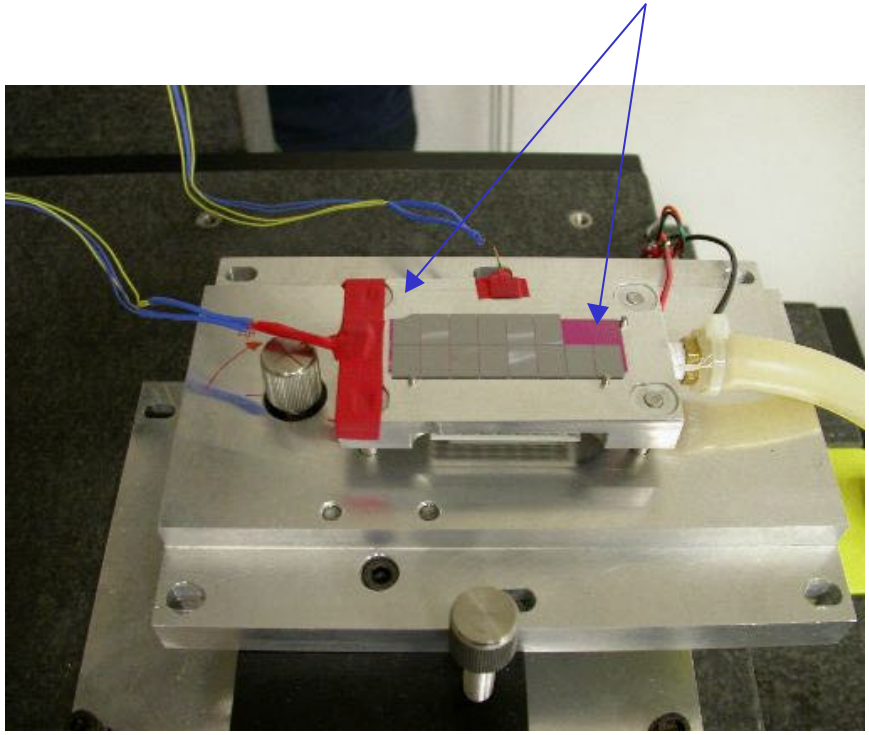


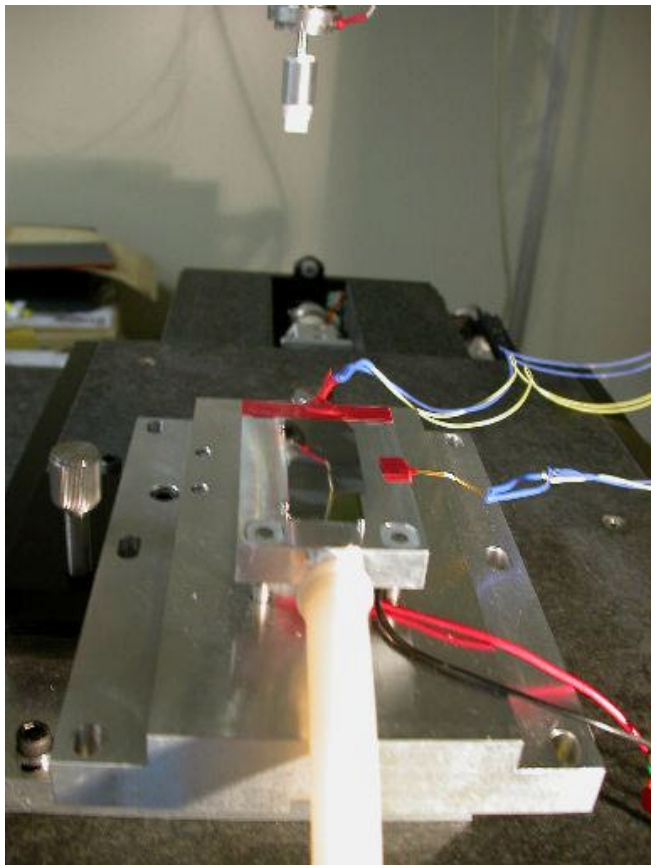
…now we can set the target chip, go there and….

…land on it keeping an eye on the force on the load cell

Conclusions

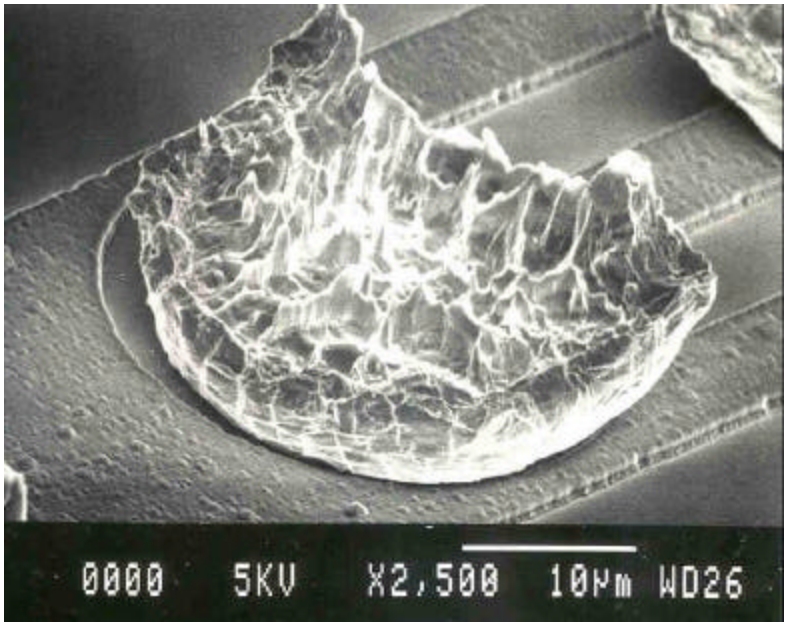
First chips have been stripped out of a dummy module that already suffered some injuries…

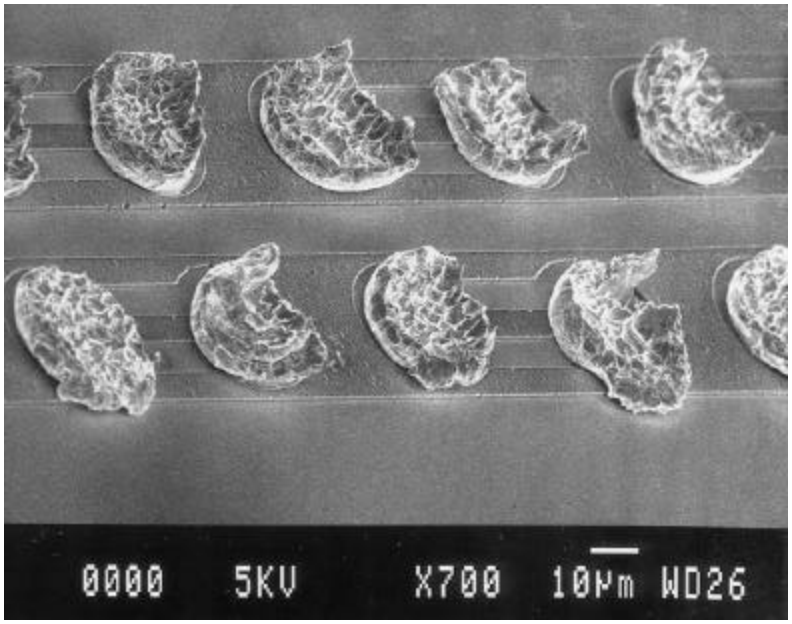




Conclusions (2)

Pictures show a plastic detachment but somehow it looks like the planarity was not as required…





The chip stripping machine is working and (almost) ready!